

What is claimed is:

1: 1. An instruction scheduling method comprising:

2       a priority calculation step of calculating a priority  
3 of each of a plurality of instructions that are subjected  
4 to scheduling, based on dependencies between the plurality  
5 of instructions and constraints of hardware resources for  
6 processing the plurality of instructions, the dependencies  
7 being data dependency, anti-dependency, and output  
8 dependency; and

9       an execution timing decision step of deciding an  
10 execution timing of an instruction having a highest  
11 priority.

1   2. The instruction scheduling method of Claim 1,

2       wherein the priority calculation step includes:

3       a precedence constraint rank calculation substep of  
4 calculating a precedence constraint rank of each of the  
5 plurality of instructions, wherein (a) if the instruction  
6 has a succeeding instruction which is anti-dependent or  
7 output dependent on the instruction, the precedence  
8 constraint rank of the instruction is equal to a precedence  
9 constraint rank of the succeeding instruction, and (b)  
10 if the instruction has a succeeding instruction which is  
11 data dependent on the instruction, the precedence  
12 constraint rank of the instruction is higher than a

13 precedence constraint rank of the succeeding instruction;  
14: and

15       a resource constraint evaluation substep of judging  
16 (i) whether the instruction has a succeeding instruction  
17 which is dependent on the instruction, (ii) whether the  
18 instruction and the succeeding instruction have an equal  
19 precedence constraint rank, and (iii) whether a hardware  
20 resource for processing the instruction cannot process  
21 the instruction and the succeeding instruction in parallel,  
22 and

23       the priority calculation step raises the precedence  
24 constraint rank of the instruction and sets the raised  
25 precedence constraint rank as a priority of the instruction  
26 if all of the judgments (i), (ii), and (iii) are in the  
27 affirmative, and sets the precedence constraint rank of  
28 the instruction as the priority of the instruction if any  
29 of the judgments (i), (ii), and (iii) is in the negative.

1   3. The instruction scheduling method of Claim 1,

2       wherein the priority calculation step includes:

3       a precedence constraint rank calculation substep of  
4 calculating a precedence constraint rank of each of the  
5 plurality of instructions, wherein (a) if the instruction  
6 has no succeeding instruction which is dependent on the  
7 instruction, the precedence constraint rank of the

8 instruction is 1, (b) if the instruction has one or more  
9 succeeding instructions which are anti-dependent or output  
10 dependent on the instruction, the precedence constraint  
11 rank of the instruction is a highest one of precedence  
12 constraint ranks of the succeeding instructions, and (c)  
13 if the instruction has one or more succeeding instructions  
14 which are data dependent on the instruction, the precedence  
15 constraint rank of the instruction is a sum of 1 and a  
16 highest one of precedence constraint ranks of the  
17 succeeding instructions; and  
18 a resource constraint evaluation substep of  
19 calculating a resource constraint value of the instruction,  
20 by dividing a total number of instructions which are to  
21 be processed by a hardware resource for processing the  
22 instruction and whose execution timings have not been  
23 decided, by a maximum number of instructions that can be  
24 processed in parallel by the hardware resource, and  
25 the priority calculation step sets the resource  
26 constraint value as a priority of the instruction if the  
27 resource constraint value is larger than the precedence  
28 constraint rank, and sets the precedence constraint rank  
29 as the priority of the instruction if the resource  
30 constraint value is no larger than the precedence  
31 constraint rank.

1 4. An instruction scheduling method for sequentially  
2 deciding execution timings of instructions that are  
3 subjected to scheduling, comprising:  
4 a decision judgment step of judging, after an  
5 execution timing of a first instruction is decided, whether  
6 an execution timing of a second instruction can be decided  
7 so as to be within a predetermined time period, based on  
8 a constraint of a hardware resource for processing the  
9 second instruction; and  
10 a redecision step of retracting, if the judgment is  
11 in the negative, the decision of the execution timing of  
12 the first instruction and deciding an execution timing  
13 of an instruction other than the first instruction.

1 5. The instruction scheduling method of Claim 4,  
2 wherein the predetermined time period is expressed  
3 by a number of clock cycles,  
4 the decision judgment step includes:  
5 a resource constraint evaluation substep of  
6 calculating a resource constraint value of the second  
7 instruction, by dividing a total number of instructions  
8 which are to be processed by the hardware resource and  
9 whose execution timings have not been decided, by a maximum  
10 number of instructions that can be processed in parallel  
11 by the hardware resource, and

12           the decision judgment step judges in the negative  
13 if the resource constraint value is larger than the number  
14 of clock cycles.

1   6. A program conversion method characterized in that:  
2       an input program is converted to an object program  
3 including a plurality of instructions, and an execution  
4 timing of each of the plurality of instructions in the  
5 object program is decided using the instruction scheduling  
6 method of one of Claims 1 to 5.

1   7. An instruction scheduling device comprising:  
2       a priority calculation unit operable to calculate  
3 a priority of each of a plurality of instructions that  
4 are subjected to scheduling, based on dependencies between  
5 the plurality of instructions and constraints of hardware  
6 resources for processing the plurality of instructions,  
7 the dependencies being data dependency, anti-dependency,  
8 and output dependency; and  
9       an execution timing decision unit operable to decide  
10 an execution timing of an instruction having a highest  
11 priority.

1   8. An instruction scheduling device for sequentially  
2 deciding execution timings of instructions that are

3 subjected to scheduling, comprising:  
4 a decision judgment unit operable to judge, after  
5 an execution timing of a first instruction is decided,  
6 whether an execution timing of a second instruction can  
7 be decided so as to be within a predetermined time period,  
8 based on a constraint of a hardware resource for processing  
9 the second instruction; and  
10 a redecision unit operable to retract, if the judgment  
11 is in the negative, the decision of the execution timing  
12 of the first instruction and decide an execution timing  
13 of an instruction other than the first instruction.

1 9. A computer-executable program for instruction  
2 scheduling, having a computer execute:

3 a priority calculation step of calculating a priority  
4 of each of a plurality of instructions that are subjected  
5 to scheduling, based on dependencies between the plurality  
6 of instructions and constraints of hardware resources for  
7 processing the plurality of instructions, the dependencies  
8 being data dependency, anti-dependency, and output  
9 dependency; and

10 an execution timing decision step of deciding an  
11 execution timing of an instruction having a highest  
12 priority.

1 10. A computer-executable program for sequentially  
2 deciding execution timings of instructions that are  
3 subjected to scheduling, having a computer execute:  
4       a decision judgment step of judging, after an  
5 execution timing of a first instruction is decided, whether  
6 an execution timing of a second instruction can be decided  
7 so as to be within a predetermined time period, based on  
8 a constraint of a hardware resource for processing the  
9 second instruction; and  
10       a redecision step of retracting, if the judgment is  
11 in the negative, the decision of the execution timing of  
12 the first instruction and deciding an execution timing  
13 of an instruction other than the first instruction.

1 11. A computer-readable storage medium storing the program  
2 of one of Claims 9 and 10.